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OIPE APR 0 2 2001 PATENT & TRADEMARK OFFICE

FORM PTO-1390 (REV 11-98) US DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE		ATTORNEY'S DOCKET NUMBER 3315/28
TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371		U.S. APPLICATION NO. (If known, see 37 CFR 1.5) 09/806713
INTERNATIONAL APPLICATION NO. PCT/GB00/02931	INTERNATIONAL FILING DATE 28 July 2000	PRIORITY DATE CLAIMED 31 July 1999
TITLE OF INVENTION COMPRESSOR DRIVE		
APPLICANT(S) FOR DO/EO/US Alan BEALE, Stephen John COOK, and Michael David NEWTON		

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☐ This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4. ☐ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. ☐ is transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☒ has been transmitted by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☐ A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☐ have been transmitted by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☒ have not been made and will not be made.
8. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☐ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 16. below concern document(s) or information included:

11. ☐ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☒ A FIRST preliminary amendment.
    ☐ A SECOND or SUBSEQUENT preliminary amendment.
14. ☐ A substitute specification.
15. ☐ A change of power of attorney and/or address letter.
16. ☒ Other items or information:

International Application Publication No. WO 01/09695 A1
Copy of Notice Informing the Applicant of the Communication of the International Application to the Designed Offices (1st page)

JC02 Rec'd PCT/PTO 02 APR 2001

U.S. APPLICATION NO. (if known, see 37 CFR 1.5) 09/806713	INTERNATIONAL APPLICATION NO PCT/GB00/02931	ATTORNEY'S DOCKET NUMBER 3315/28

17. [X] The following fees are submitted: **BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)):** Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO .... **$970.00** International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO....... **$840.00** International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO .... **$760.00** International preliminary examination fee paid to USPTO (37 CFR 1.482) but all claims did not satisfy provisions of PCT Article 33(1)-(4) .... **$670.00** International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(1)-(4) **$96.00**				**CALCULATIONS**	PTO USE ONLY
ENTER APPROPRIATE BASIC FEE AMOUNT =				$ 860.00	
Surcharge of **$130.00** for furnishing the oath or declaration later than [ ] 20 [ ] 30 months from the earliest claimed priority date (37 CFR 1.492(e)).				$	
CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total claims	13 - 20 =	0	X **$18.00**	$ 0	
Independent claims	3 - 3 =	0	X **$78.00**	$ 0	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)		0	+ **$260.00**	$ 0	
TOTAL OF ABOVE CALCULATIONS =				$ 860.00	
Reduction of 1/2 for filing by small entity, if applicable. A Small Entity Statement must also by filed (Note 37 CFR 1.9, 1.27, 1.28).				$	
SUBTOTAL =				$	
Processing fee of **$130.00** for furnishing the English translation later than [ ] 20 [ ] 30 months from the earliest claimed priority date (37 CFR 1.492(f)). +				$	
TOTAL NATIONAL FEE =				$ 860.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property +				$	
TOTAL FEES ENCLOSED =				$ 860.00	
				Amount to be: refunded	$
				charged	$

a. [X] A check in the amount of $ 860.00 to cover the above fees is enclosed.

b. [ ] Please charge my Deposit Account No. ________ in the amount of $________ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. [X] The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 02-4270. A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

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PATENT
ATTORNEY DOCKET NO. 3315-28

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	Alan Beale et al.	
Serial No.:	To be Assigned, National Stage Filing Based on PCT Appl. No. PCT/GB00/02931	
Filed:	Concurrently Herewith	Examiner: To be Assigned
Title:	COMPRESSOR DRIVE	Group Art Unit: To be Assigned

BOX NON-FEE AMENDMENT
Assistant Commissioner for Patents
Washington, D.C. 20231

PRELIMARY AMENDMENT

Sir:

This is a preliminary amendment to the U.S. national phase patent application that is based upon the priority of International Publication Number WO 01/09695.

IN THE SPECIFICATION

At Page 1, Line 2, please add: --Field of the Invention--

At Page 1, Line 7, before "Conventionally electromagnetic pumps operate from"; please add: --Background of the Invention--

At Page 2, Line 9, please delete "The aim of the present invention is to provide" and substitute: --Thus, those skilled in the art have long recognized the need for—

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At Page 2, Line 14, before "Accordingly, the present invention provides a fluid"; please add: --Summary of the Invention--

At Page 4, Line 6, before "Figure 1 shows a block diagram of the fluid flow"; please add: --Brief Description of the Drawings--

At Page 4, Line 24, before "Referring to the block diagram at Figure 1 there is"; please add: --Detailed Description Of The Preferred Embodiments--

At Page 8, Line 14, delete "10"; and substitute therefor --16--.

At Page 8, Line 29, delete "10"; and substitute therefor --16--.

At Page 9, Line 8, delete "10"; and substitute therefor --17--.

At Page 9, Line 22, delete "10"; and substitute therefor --17--.

At Page 9, Line 27, delete "10"; and substitute therefor --17--.

At Page 10, Line 7, delete "10"; and substitute therefor --18--.

At Page 10, Line 21, delete "10"; and substitute therefor --18--.

At Page 10, Line 26, delete "10"; and substitute therefor --18--.

At Page 10, Line 29, please add: --Furthermore, the various embodiments described above are provided by way of illustration only and should not be construed to limit the invention. Those skilled in the art will readily recognize various modifications and changes may be made to the present invention without departing from the true spirit and scope of the present invention. Accordingly, it is not intended that the invention be limited, except as by the appended claims.--

At Page 13, Line 21, please add: --Abstract of the Invention

A fluid flow control system for an electromagnetic pump having an electromagnetic drive (11) and a compressor (6). The control system established a required current in the compressor coils (10) to control the position and movement of the actuator (11), the actuator deflecting a diaphragm within the pump to provide the required flow. The control system includes a command signal generator (1) to create a signal representing the required flow. The signal is applied to a command processor (2) with any feedback signals (13) for example, coil current and/or actuator displacement. The command processor (2) calculates the appropriate drive signal defined by mark-space ratio, repetition rate, and amplitude. The drive signal controls the voltage supplied to the compressor coils (11) resulting in a required coil current to provide the desired flow. A dc power supply is used to avoid problems regarding main power supply and frequency.--

<u>IN THE DRAWINGS</u>

In Figure 4, the part number for the actuator position sensor has been changed from 10 to 16.

In Figure 5, the part number for the flow sensor has been changed from 10 to 17.

In Figure 6, the part number for the pressure sensor has been changed from 10 to 18.

Formal drawings incorporating the above changes will be sent to the Official Draftsman under separate cover.

<u>IN THE CLAIMS</u>

Please delete claim 14.

Please amend the claims 1-13 to read as follows:

1. A fluid flow control system for an electromagnetic pump, the control system comprising:

an electromagnetic drive means within a compressor, wherein the control system supplies a pulse width modulated drive signal to the electromagnetic drive means so as to provide a predetermined pump flow rate, and wherein the drive signal is generated by a dc voltage supply.

2. The fluid flow control system of claim 1, wherein the pulse width modulated drive signal comprises variable mark space ratio pulses with defined repetition rates and amplitude.

3. The fluid flow control system of claim 1, wherein the electromagnetic drive means includes at least one stator of magnetic material, at least one excitation winding for magnetically exciting the at least one stator, and a movable magnetic member connected to an actuator of the compressor.

4. The fluid flow control system of claim 1, further comprising as least one diaphragm, wherein the electromagnetic drive means is operatively associated with the at least one diaphragm to provide conversion of electrical energy to fluid flow.

5. The fluid flow control system claim 1, further comprising excitation windings having instantaneous current, and wherein the pulse width modulated drive signal controls the instantaneous current within the excitation windings.

6. The fluid flow control system of claim 1, wherein the drive signal includes a mark-space ratio, and wherein the mark-space ratio of the drive signal defines over time an approximate half sine wave current waveform.

7. The fluid flow control system of claim 1, wherein the pulse width modulated drive signal is of substantially constant amplitude.

8. A fluid flow control system for an electromagnetic pump, the control system comprising;

an electromagnetic drive means within a compressor, wherein the control system supplies a pulse width modulated low voltage drive signal of substantially fixed amplitude to the electromagnetic drive means, wherein the electromagnetic drive means includes coils having current, and wherein the pulse width modulated low voltage drive signal controls amplitude and repetition rate of the current in the coils of the electromagnetic drive means to drive an actuator of the compressor in order to generate a desired flow rate output from the compressor.

9. A fluid flow control system for an electromagnetic pump, the control system comprising;

an electromagnetic drive means within a compressor, wherein the control system further comprises:

a command generator that creates a command signal corresponding to a predetermined desired fluid flow rate;

at least one sensor to ascertain the status of the system and provide at least one feedback signal,

wherein the command signal and the at least one feedback are processed by a command processor, wherein the command processor outputs a drive signal defined by a mark-space ratio, a repetition rate, and an amplitude, and wherein the drive signal controls voltage applied to compressor windings.

10. The fluid flow control system of claim 1, wherein the at least one sensor provides feedback to the command processor regarding instantaneous coil current.

11. The fluid flow control system of claim 1, wherein the at least one sensor provides feedback to the command processor regarding actuator displacement.

12. The fluid flow control system of claim 1, wherein the at least one sensor provides feedback to the command processor regarding bladder system pressure.

13. The fluid flow control system of claim 1, wherein the at least one sensor provides feedback to the command processor regarding bladder system fluid flow.

PLEASE SEE THE ATTACHED PAGES SHOWING THE AMENDMENTS IN FULL DETAIL.

1. (Amended) A fluid flow control system for an electromagnetic pump, the control system comprising:

an electromagnetic drive means within a compressor, wherein the control system [supplying] supplies a pulse width modulated drive signal to the electromagnetic drive means so as to [supply] provide a predetermined pump flow rate, and wherein the drive signal is generated [from] by a dc voltage supply.

2. (Amended) The [A] fluid flow control system [as claimed in] of claim 1, wherein the pulse width modulated drive signal comprises [a train of] variable mark space ratio pulses with defined repetition rates and amplitude.

3. (Amended) The [A] fluid flow control system [as claimed in of claims 1 or 2] of claim 1, wherein the electromagnetic drive means includes at least one stator[(s)] of magnetic material, at least one excitation winding[(s)] for magnetically exciting the at least one stator[(s)], and a movable magnetic member connected to [the] an actuator of the compressor.

4. (Amended) The [A] fluid flow control system [as claimed in] of claim 1 [3], further comprising at least one diaphragm, wherein the electromagnetic drive means [in combination with diaphragms] is operatively associated with the at least one diaphragm to provide [provides a] conversion of electrical energy to fluid flow.

5. (Amended) The [A] fluid flow control system [as claimed in any preceding] claim 1, further comprising excitation windings having instantaneous current, and wherein the pulse width modulated drive signal controls the instantaneous current within the excitation windings.

6. (Amended) The [A] fluid flow control system [as claimed in] of claim 1 [5], wherein the drive signal includes a mark-space ratio, and wherein the mark-space ratio of the drive signal defines [with] over time an approximate half sine_wave current waveform.

7. (Amended) The [A] fluid flow control system [as claimed in] of claim 1 [6], wherein the pulse width modulated drive signal is of substantially constant amplitude.

8. (Amended) A fluid flow control system for an electromagnetic pump, the control system comprising:

an electromagnetic drive means within a compressor, wherein the control system [supplying] supplies a pulse width modulated low voltage drive signal of substantially fixed amplitude to the electromagnetic drive means, wherein the electromagnetic drive means includes coils having current, and wherein the pulse width modulated low voltage drive signal [to control the] controls amplitude and repetition rate of the current in the coils of the electromagnetic drive means to drive [the] an actuator of the compressor in order to generate a desired flow rate output from the compressor.

10. (Amended) A fluid flow control system for an electromagnetic pump, the control system comprising:

an electromagnetic drive means within a compressor, wherein the control system further comprises: [including]

a command generator that creates [creating] a command signal corresponding to a predetermined desired fluid flow rate;[,]

at least one sensor[(s)] to [sense] ascertain the status of the system and provide at least one feedback signal[(s)],

wherein the command signal and the at least one feedback [signal(s) being] are processed by a command processor, wherein the command processor [providing] outputs a drive signal [output, the drive signal] defined by a mark-space ratio, a repetition rate, and an amplitude, and wherein the drive signal controls [controlling the] voltage [to be] applied to [the] compressor windings.

10. (Amended) The [A] fluid flow control system [as claimed in] of claim 1 [9], wherein the at least one sensor[(s)] provides feedback to the command processor regarding [of] instantaneous coil current.

11. (Amended) The [A] fluid flow control system [as claimed in] of claim 1 [9], wherein the at least one sensor[(s)] provides feedback to the command processor regarding [of] actuator displacement.

12. (Amended) The [A] fluid flow control system [as claimed in] of claim 1 [9], wherein the at least one sensor[(s)] provides feedback to the command processor regarding [of] bladder system pressure.

13. (Amended) The [A] fluid flow control system [as claimed in] of claim 1 [9], wherein the at least one sensor[(s)] provides feedback to the command processor regarding [of] bladder system fluid flow [into/out of bladder system].

REMARKS

This is a preliminary amendment. Applicants have carefully reviewed the application and herein provide the above amendments to conform them more closely to U.S. claiming practice.

CLOSURE

If the Examiner has any questions concerning the foregoing, the Examiner is invited to telephone the undersigned attorney at (212) 703-1329. The undersigned attorney can normally be reached Monday through Friday from about 8:30 AM to 5:30 PM Eastern time.

Respectfully submitted,

Dated: April 2, 2001

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COMPRESSOR DRIVE

The present invention relates to a fluid flow control system and particularly a fluid flow control system for an electromagnetic pump which can provide any desired variable fluid flow rate.

Conventionally electromagnetic pumps operate from mains power and the compressors within the electromagnetic pumps operate directly from this single phase mains power which provides the compressor electrical drive input voltage and frequency. Therefore these compressors operate at constant fluid flow, and any fluid flow control depends merely on on/off control or on fluid loading conditions. The necessary fluid flow rates are obtained by the control and design of the fluid routing system.

Such compressors include linear or arcuate motion reciprocating actuators driven by electromagnetic drive means supplied by the mains power voltage and frequency. The electromagnetic drive means drive the actuators into reciprocating mechanical motion which is translated by diaphragms and valves into fluid flow from one or more compressor inputs to one or more compressor outputs.

This approach has a number of problems including the design of the compressor having to vary with the value of mains power voltage and frequency, complicating manufacture and driving up costs. Furthermore, flow control only by air routing compromises the compressors' life, the compressors having to be operated continually at maximum capacity with the consequence of maximum noise and vibration during use.

Furthermore, the performance of the compressors is largely dependent on the mechanical characteristics of its components, for example the diaphragm stiffness, the moving mass, and also the stiffness of the compressed air within the pump.

Any variation either between units of manufacture or within environmental operating conditions or through use will cause additional performance variation.

The aim of the present invention is to provide a fluid flow control system for an electromagnetic pump that is not dependent on the voltage and frequency of the mains power supply and provides the desired fluid flow with the optimum performance of the pump.

Accordingly, the present invention provides a fluid flow control system for an electromagnetic pump comprising electromagnetic drive means within a compressor, the control system supplying a pulse width modulated drive signal to the electromagnetic drive means so as to supply a predetermined pump flow rate, the drive signal generated from a dc voltage supply.

Preferably, the pulse width modulated drive signal comprises a train of variable mark space ratio pulses with defined repetition rates and amplitude. By varying the mark space ratio with time and appropriately defining its repetition rate and amplitude a drive signal compatible with the required flow rate can be obtained.

Preferably, the electromagnetic drive means includes stator(s) of magnetic material, excitation winding(s) for magnetically exciting the stator(s) and a movable magnetic member connected to the actuator of the compressor. An actuator deflection results in a corresponding deflection

of the attached diaphragm(s) and in flow of any fluid in contact with the diaphragm(s).

Preferably, the electromagnetic drive means in combination with diaphragms provides a conversion of electrical energy to fluid flow.

Preferably, the pulse width modulated drive signal controls the instantaneous current within the excitation windings. This current by controlling actuator deflection amplitude and repetition rate controls fluid flow within the compressor.

Preferably the mark-space ratio of the drive signal defines with time an approximate half sinewave waveform.

Preferably, the pulse width modulated drive signal is of substantially constant amplitude. Pulse width modulated control from a dc power supply ensures the compressor is always operating with optimum efficiency for any application, the compressor performance being independent of mains power type or variations and allowing the possibility of using batteries to operate the pumps. Therefore, the problems associated with existing fixed frequency mains voltage driven compressors and pumps are avoided.

According to a further aspect of the present invention, there is provided a fluid flow control system for an electromagnetic pump comprising electromagnetic drive means within a compressor, the control system supplying a pulse width modulated low voltage drive signal of substantially fixed amplitude to the electromagnetic drive means to control the amplitude and repetition rate of the current in the coils of the electromagnetic drive

means to drive the actuator in order to generate a desired flow rate output from the compressor.

Preferred embodiments of the present invention will now be described in detail by way of example only, with reference to the accompanying drawings of which:

Figure 1 shows a block diagram of the fluid flow control system according to the present invention;

Figure 2a shows the bipolar voltage drive signal;

Figure 2b shows the unipolar drive signal from the mark space/repetition rate generator;

Figure 2c shows actuator current;

Figure 3 shows a block diagram of one embodiment of a control system of Figure 1 supplying fluid to a bladder; and

Figure 4 shows a block diagram of another embodiment of a control system of Figure 1 supplying fluid to a bladder;

Figure 5 shows a block diagram of a further embodiment of a control system of Figure 1 supplying fluid to a bladder; and

Figure 6 shows a block diagram of a further embodiment of a control system of Figure 1 supplying fluid to a bladder.

Referring to the block diagram at Figure 1 there is shown a controlled fluid flow system comprising a control system, fluid routing, a bladder system (7) and a compressor comprising one or more diaphragms (12) attached to an electromagnetic actuator (11).

The control system establishes a required current in the compressor (6) coil or coils (10) at any instant in time. The coil current controls the position of the

actuator (11) which deflects the diaphragm(s) (12) appropriately thereby providing flow of any fluid in contact with the diaphragm(s)(12). Controlling the current in the coil(s)(10) controls the fluid flow from the compressor (6).

A command signal representing the required fluid flow is created in the command generator (1) and applied to the command processor (2) in conjunction with any feedback signal(s)(13) derived from the coil current sensor, actuator position sensor, bladder flow sensor and bladder pressure sensor. They provide signals representing instantaneous coil current, actuator displacement flow into or out of the bladder system (7) and bladder system (7) pressure.

The output of the command generator (1) and the feedback signals (13) are processed in the command processor (2) using a control algorithm which is representative of the pneumatic, mechanical and electrical characteristics of the compressor that is to be driven. From the control algorithm an appropriate drive signal is calculated, defined by mark-space ratio, repetition rate and amplitude parameters.

Drive signal amplitude is obtained via the amplitude controller (5) appropriately changing the power supply interface (14) within the power amplifier (4) to change the dc supply voltage of the 'H' bridge driver (15). The drive signal mark-space ratio and repetition rate are obtained by the mark-space and repetition rate generator operating on the appropriate parameter values. The generator provides a unipolar drive signal to the 'H'

bridge driver (15) which then provides a bipolar voltage drive signal to the compressor coil(s) (10).

This bipolar voltage drive signal (Figure 2a) across the compressor coils may be represented by repetition rate 1/A, mark-space ratio B/A and amplitude switching between +V and -V. V is a voltage closely approximating the supply voltage to the 'H' bridge driver (15). Typically V might be around 12 volts with a repetition rate of several kilohertz and mark-space ratio varying from below one per cent to above 99 per cent.

If for the purposes of obtaining appropriate compressor fluid flow an actuator current of period x is required (Figure 2c) then over a time period of x the generator (3) will provide mark-space ratio values approximating two half sinusoids (Figure 2b), each over a period of x/2 and with uniform repetition rate. This drive signal combined with the switching action of the 'H' bridge driver (Figure 2-a) will create a complete bipolar near sinusoidal actuator coil current with a period of x as required. Typically x will be ten to a hundred times greater than A requiring a drive signal repetition rate equally much higher than 1/x.

The bipolar current in the compressor coil(s) enables the actuator to be displaced both positively and negatively with respect to its non-energised position. The actuator displacement results in the fluid pumping diaphragm(s) (12) being deflected to the required amount to provide the required flow rate of the fluid. The power amplifier (4) is supplied from mains power via a regulated or unregulated dc supply or from a dc battery.

It will be apparent to skilled practitioners of the art that for the invention except where indicated otherwise the command generator, mark-space and repetition rate generator, command processor, dc supply, power amplifier and amplitude controller can be implemented in any combination of analogue circuitry, digital circuitry or state machines including microprocessor systems.

It will also be apparent to skilled practitioners of the art that instead of diaphragms one can use other air displacement devices such as pistons, vanes, spirals, and that fluid flow out of as well as into the bladder system can be controlled.

Figure 3 shows a preferred embodiment of the invention where the characteristics of the compressor output fluid flow are known for varying loads, temperatures and pressures. In this case, a command signal representing the required fluid flow is created in the command generator (1) and applied to the command processor (2). The command processor (2) determines the repetition rate and mark-space ratio required from the mark-space and repetition rate generator (3) This results in a variable repetition rate and time varying mark-space ratio waveform representative of the current required in the compressor (6) coil or coils. The waveform is applied to the power amplifier (4) where it is controlled in amplitude by the amplitude controller (5), the amplitude being determined by the command processor (2). The output of the power amplifier (4) provides a voltage with the amplitude repetition rate and mark-space ratio controlled by the command processor. This voltage is applied to the compressor (6) coil or coils resulting in a known current,

therefore a known deflection of the compressor bellows and thus a known amount of fluid flow to the bladder system (7) by way of the fluid routing system (8). A dc power supply (9) is used.

Figure 4 shows the control of the fluid flow system as described in Figure 3 but applied to the control of the actuator position within the compressor by actuator position feedback. This control approach removes the effect of unknown variations within the electromagnetic drive means between drive signal and resulting actuator deflection.

A command signal representing the required fluid flow is created in the command generator (1) and added to the actuator position sensor (10) signal in the command processor (2) thus providing an error signal to ensure that the actuator position is achieved. This error signal from the command processor (2) determines the repetition rate and mark-space ratio required from the mark-space and repetition rate generator (3). This results in a variable repetition rate and time varying mark-space ratio waveform representative of the current required in the compressor (6) coil or coils. This waveform is applied to the power amplifier (4) where it is controlled in amplitude by the amplitude controller (5), the amplitude being determined by the command processor (2). The output of the power amplifier (4) provides a voltage with the amplitude repetition rate and mark-space ratio controlled by the command processor (2) and the actuator position sensor (10). This voltage is applied to the compressor (6) coil or coils resulting in a known deflection of the compressor bellows and thus a known amount of fluid flow to the

bladder system (7) by way of the fluid routing system (8). A dc power supply (9) may also be used.

Figure 5 shows flow control based on the principle that the actual fluid flow into a bladder is monitored to maintain the required fluid flow.

A command signal representing the required fluid flow is created in the command generator (1) and added to the information from the flow sensor (10) in the command processor (2) thus providing an error signal to correct any error in the required flow. This error signal from the command processor (2) determines the repetition rate and mark-space ratio required from the mark-space and repetition rate generator (3). This results in a variable repetition rate and time varying mark-space ratio waveform representative of the current required in the compressor (6) coil or coils. This waveform is applied to the power amplifier (4) where it is controlled in amplitude by the amplitude controller (5), the amplitude being determined by the command processor (2). The output of the power amplifier (4) provides a voltage with the amplitude repetition rate and mark-space ratio controlled by the command processor (2) and the flow sensor (10). This voltage is applied to the compressor (6) coil or coils resulting in a deflection of the compressor bellows and thus an amount of fluid flow to the bladder system (7) by way of the fluid routing system (8). Any errors in the flow being detected by the flow sensor (10) and being used as a correction signal into the command processor (2). A dc power supply (9) is used.

Alternatively, instead of flow being monitored, the actual pressure in the bladder may be monitored as shown in Figure 6.

Referring to Figure 6, a command signal representing the required bladder pressure is created in the command generator (1) and added to the information from the pressure sensor (10) in the command processor (2) thus providing an error signal that can be used to correct any error in the required bladder system (7) pressure. This error signal from the command processor (2) determines the repetition rate and mark-space ratio required from the mark-space and repetition rate generator (3). This results in a variable repetition rate and time varying mark-space ratio waveform representative of the current required in the compressor (6) coil or coils. This waveform is applied to the power amplifier (4) where it is controlled in amplitude by the amplitude controller (5), the amplitude being determined by the command processor (2). The output of the power amplifier (4) provides a voltage with the amplitude repetition rate and mark-space ratio controlled by the command processor (2) and the pressure sensor (10). This voltage is applied to the compressor (6) coil or coils resulting in a deflection of the compressor bellows and thus an amount of fluid flow to the bladder system (7) by way of the fluid routing system (9). Any errors in the pressure detected by the pressure sensor (10) is then used as a correction signal into the command processor {2). A dc power supply is used (9).

Claims:

1. A fluid flow control system for an electromagnetic pump comprising electromagnetic drive means within a compressor, the control system supplying a pulse width modulated drive signal to the electromagnetic drive means so as to supply a predetermined pump flow rate, the drive signal generated from a dc voltage supply.

2. A fluid flow control system as claimed in claim 1, wherein the pulse width modulated drive signal comprises a train of variable mark space ratio pulses with defined repetition rates and amplitude.

3. A fluid flow control system as claimed in claims 1 or 2, wherein the electromagnetic drive means includes stator(s) of magnetic material, excitation winding(s) for magnetically exciting the stator(s) and movable magnetic member connected to the actuator of the compressor.

4. A fluid flow control system as claimed in claim 3, wherein the electromagnetic drive means in combination with diaphragms provides a conversion of electrical energy to fluid flow.

5. A fluid flow control system as claimed in any preceding claim, wherein the pulse width modulated drive signal controls the instantaneous current within the excitation windings.

6. A fluid flow control system as claimed in claim 5, wherein the mark-space ratio of the drive signal defines with time an approximate half sinewave current waveform.

7. A fluid flow control system as claimed in claim 6, wherein the pulse width modulated drive signal is of substantially constant amplitude.

8. A fluid flow control system for an electromagnetic pump comprising electromagnetic drive means within a compressor, the control system supplying a pulse width modulated low voltage drive signal of substantially fixed amplitude to the electromagnetic drive means to control the amplitude and repetition rate of the current in the coils of the electromagnetic drive means to drive the actuator in order to generate a desired flow rate output from the compressor.

9. A fluid flow control system for electromagnetic pump comprising electromagnetic drive means within a compressor, the control system including a command generator creating a command signal corresponding to a predetermined desired fluid flow rate, sensor(s) to sense status of the system and provide feedback signal(s), the command signal and feedback signal(s) being processed by a command processor, the command processor providing a drive signal output, the drive signal defined by mark-space ratio, repetition rate and amplitude and controlling the voltage to be applied to the compressor windings.

10. A fluid flow control system as claimed in claim 9, wherein the sensor(s) provides feedback of instantaneous coil current.

11. A fluid flow control system as claimed in claim 9, wherein the sensor(s) provides feedback of actuator displacement.

12. A fluid flow control system as claimed in claim 9, wherein the sensor(s) provides feedback of bladder system pressure.

13. A fluid flow control system as claimed in claim 9, wherein the sensor(s) provides feedback of fluid flow into/out of bladder system.

14. A fluid flow control system substantially as hereinbefore described and with reference to the accompanying Figures 1 to 6.

Fig.1.

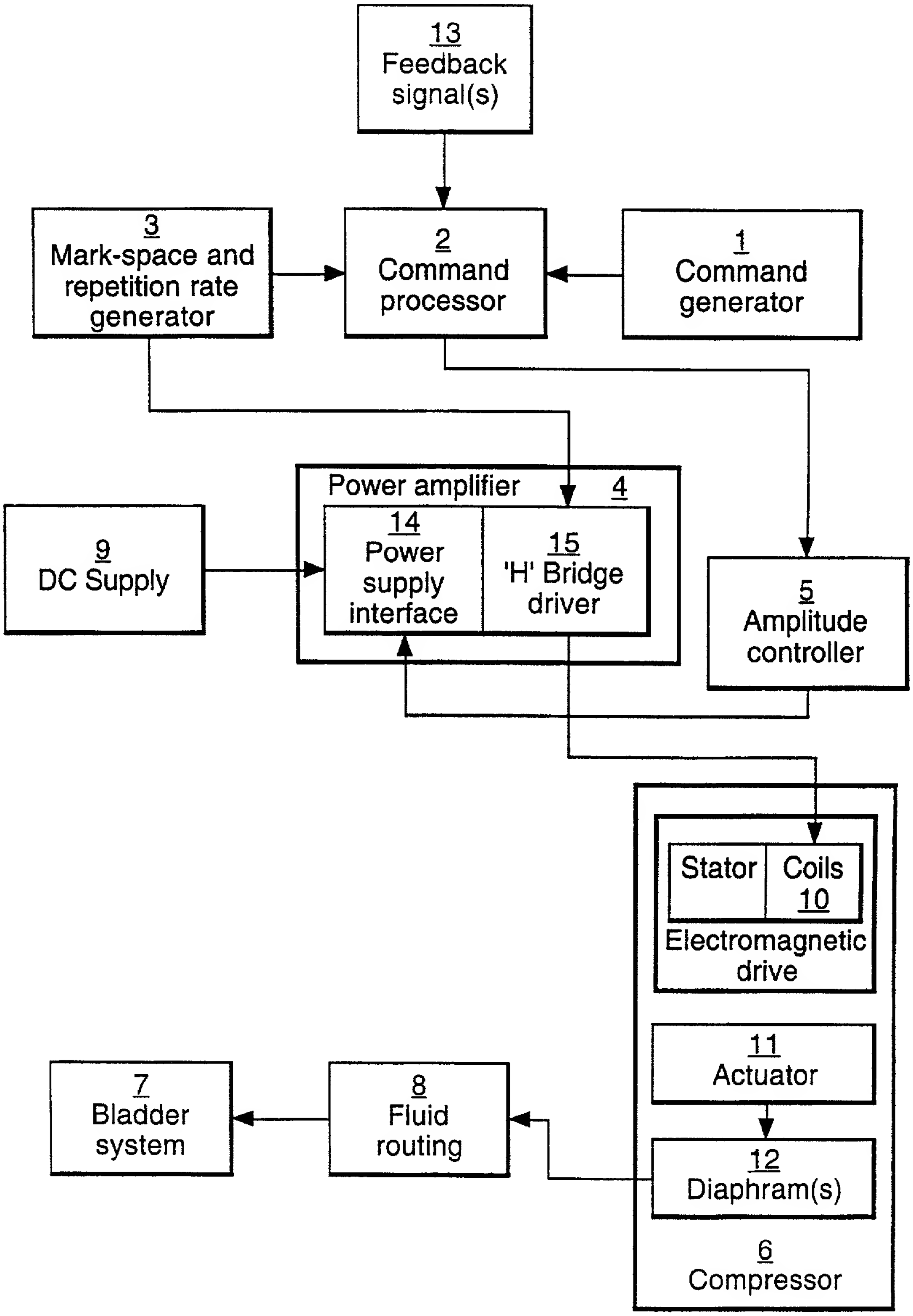
13
Feedback signal(s)
3
Mark-space and repetition rate generator
2
Command processor
1
Command generator
Power amplifier
4
9
DC Supply
14
Power supply interface
15
'H' Bridge driver
5
Amplitude controller
Stator
Coils
10
Electromagnetic drive
11
Actuator
7
Bladder system
8
Fluid routing
12
Diaphram(s)
6
Compressor

Fig.2a.

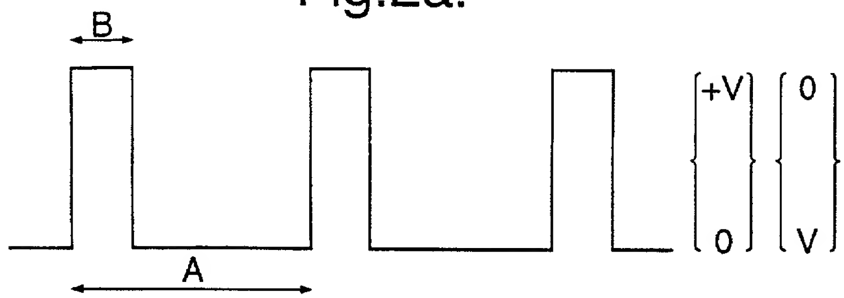

Fig.2b.

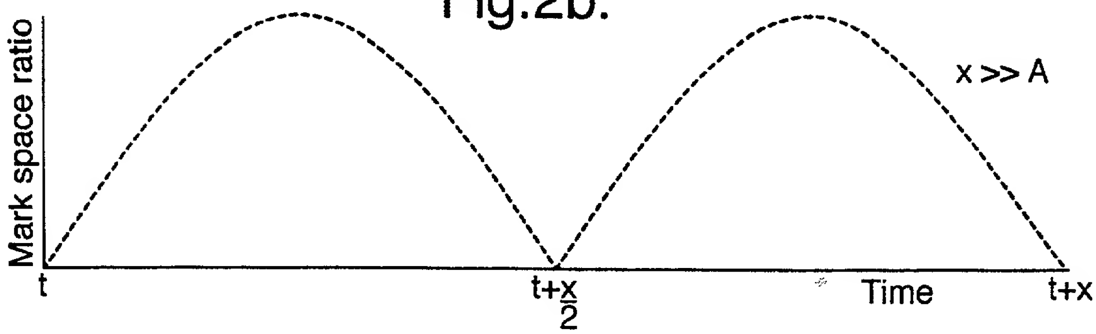

Fig.2c.

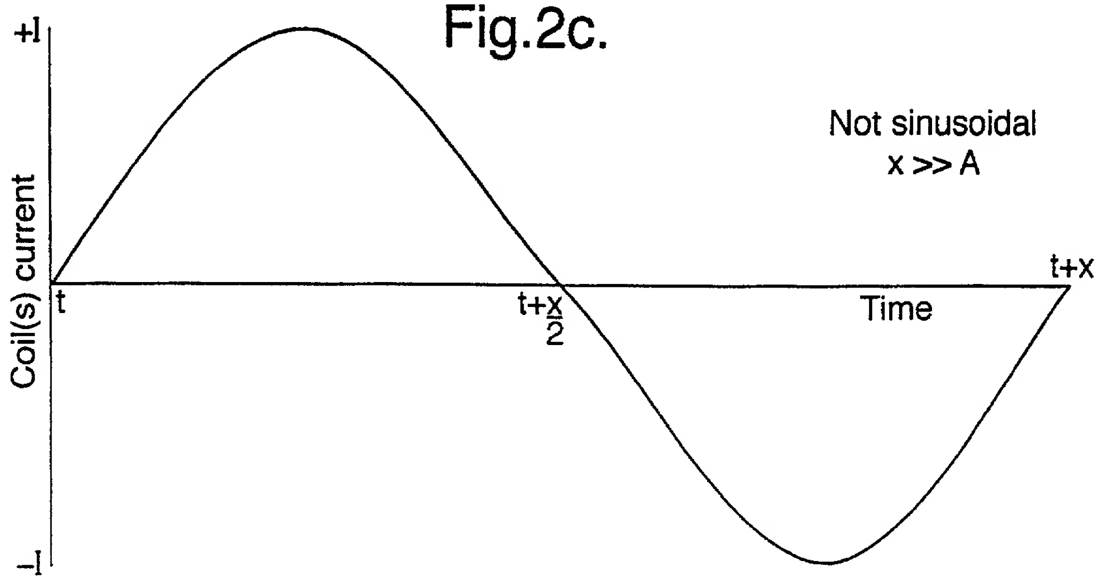

Fig.3.

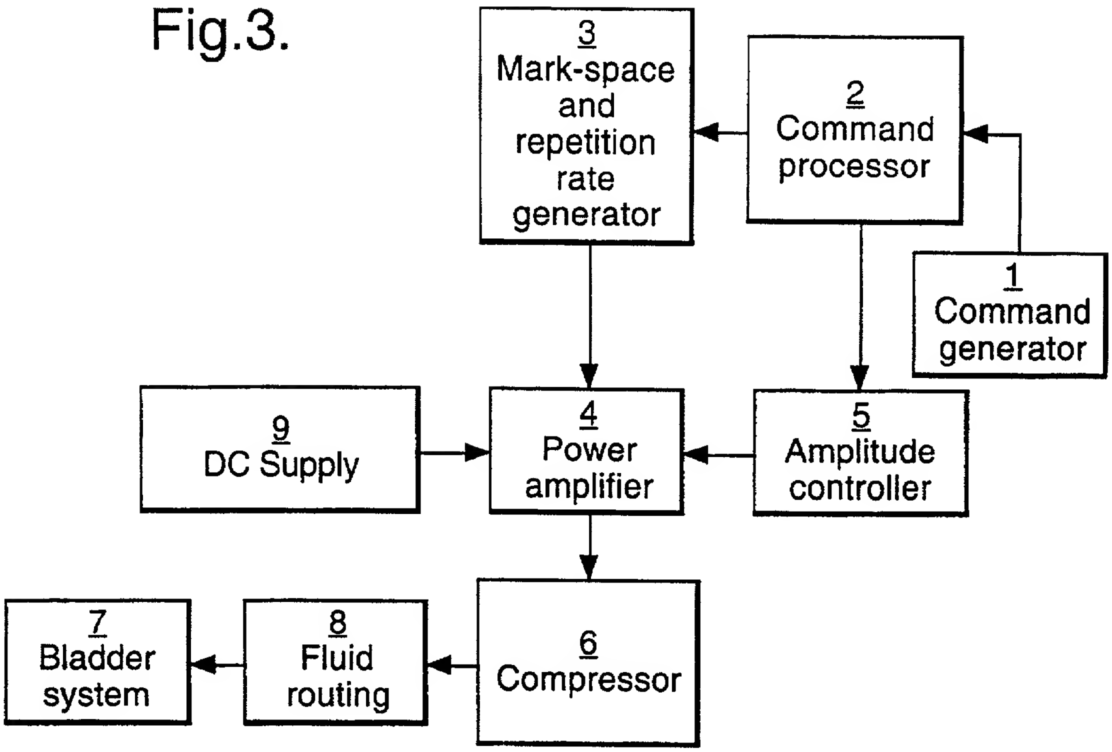
3
Mark-space and repetition rate generator
2
Command processor
1
Command generator
9
DC Supply
4
Power amplifier
5
Amplitude controller
7
Bladder system
8
Fluid routing
6
Compressor

Fig.4.

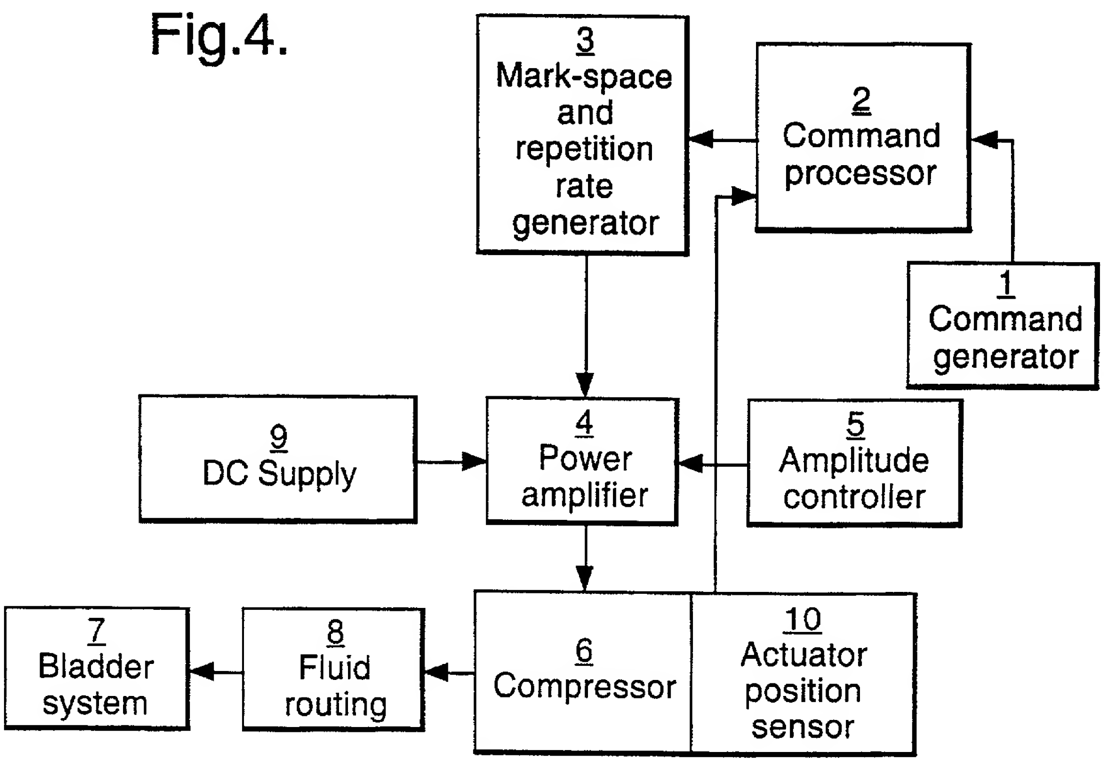
3
Mark-space and repetition rate generator
2
Command processor
1
Command generator
9
DC Supply
4
Power amplifier
5
Amplitude controller
7
Bladder system
8
Fluid routing
6
Compressor
10
Actuator position sensor

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Fig.5.

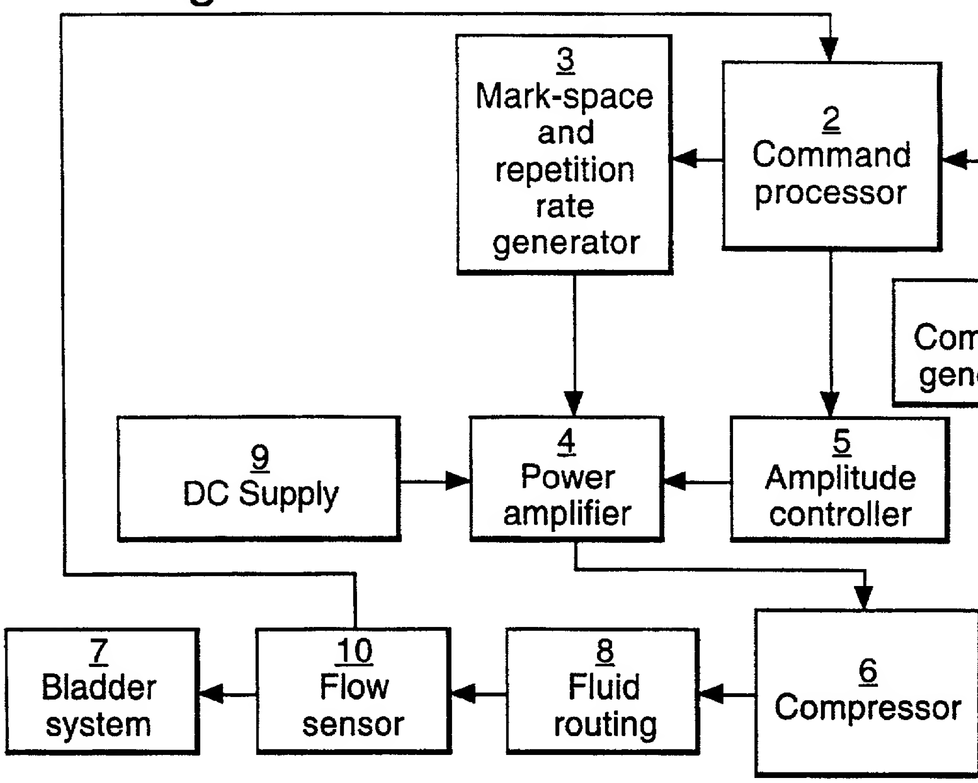
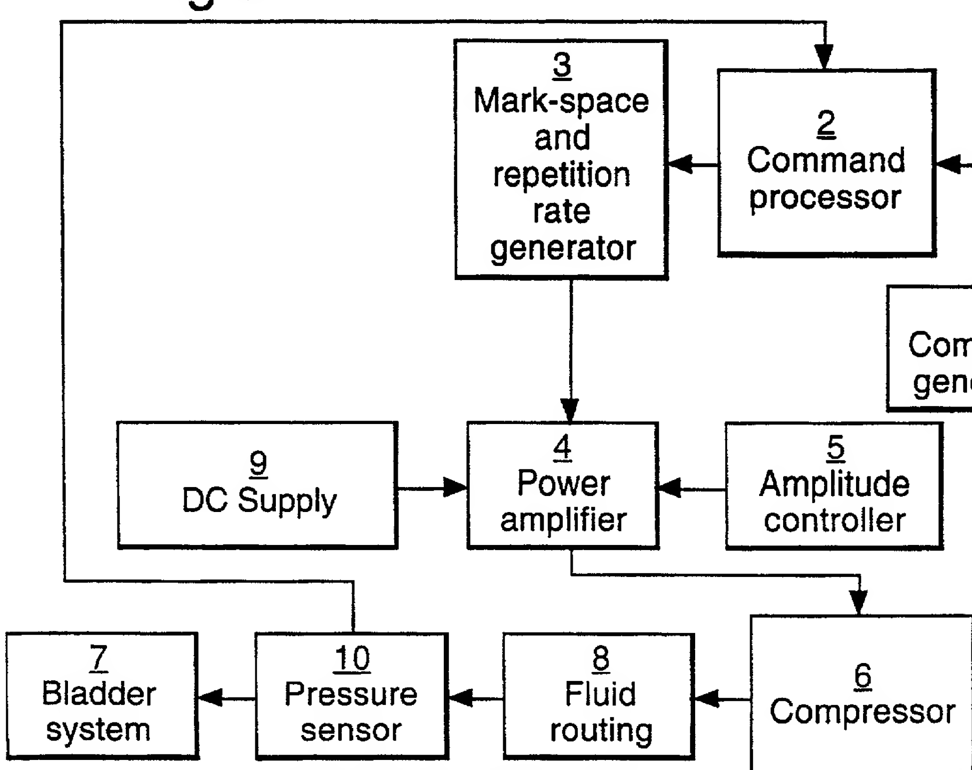


Fig.6.



DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION

(COMPLETE IF KNOWN)

Application Number	To be assigned
Filing Date	Herewith
Group Art Unit	To be assigned
Examiner	To be assigned

Attorney Docket Number	3315/28
First Named Inventor	Beale

This declaration is *(check one)*:
☒ submitted with initial filing;
☐ submitted after initial filing;
☐ a supplemental declaration.

This application is of the following type:
☐ utility;
☐ design;
☒ national stage of PCT;
☐ divisional, continuation or continuation-in-part.

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (*if only one name is listed below*) or an original, first and joint inventor (*if plural names are listed below*) of the subject matter which is claimed and for which a patent is sought on the invention entitled

COMPRESSOR DRIVE

the specification of which: *(check one)*
☐ is attached hereto; or
☐ was filed on ________ as U.S. Application Serial No. ___/______ and is/was amended on ___________ *(if applicable)*;
☒ was described and claimed in PCT International Application No. PCT/GB00/02931, filed on July 28, 2000 and was amended under PCT Article 19 on __________ *(if applicable)*.

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, §1.56.

I hereby identify below, and where indicated claim foreign priority benefits under Title 35, United States Code §§ 119(a)-(d) or §§ 365(a)-(b) of any foreign application(s) for patent or inventor's certificate or of any PCT international application(s) designating at least one country other than the United States of America, filed within 12 months (6 months for design) prior to this application, and have also identified below any foreign application(s) for patent or inventor's

certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) on which priority is claimed *(if any)*:

Foreign/PCT Application Number	Country	Filing Date (MM/DD/YYYY)	Priority Claimed	
9917961.6	Great Britain	07/31/1999	☒ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No

I hereby claim the benefit under Title 35, United States Code, §119(e) of any United States provisional application(s) listed below (if any):

Provisional Application No.	Filing Date

I hereby claim the benefit under Title 35, United States Code, § 120 of any United States application(s), or § 365(c) of any PCT International Application designating the United States of America listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT international application in the manner provided by the first paragraph of Title 35, United States Code, § 112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, § 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application:

U.S./PCT Parent Application No.	Filing Date	Status (*Patented, Pending, or Abandoned*)
PCT/GB00/02931	07/28/2000	Pending

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

As a named inventor, I hereby appoint the following attorney(s) or agent(s) with full power of substitution and revocation to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith:

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